A Self-Learning Resource From MSU Extension

MONTANA STATE UNIVERSITY EXTENSION

MontGuide

How Montana agriculture can respond to changing weather and climate patterns

by Megan Mills-Novoa, Madison Boone, and Zach Brown, all of One Montana; Brad Bauer, Gallatin County Extension Agent; and Brent Sarchet, Lewis and Clark County Extension Agent

reviewed by Dr. Bruce Maxwell, Montana State University

Montana's farmers and ranchers are at the frontline of coping with climatic variability and increasing temperatures.

MT201704AG New 7/17

MONTANA'S FARMERS AND RANCHERS ARE AT the frontline of coping with climatic variability and increasing temperatures. Montana's 27,500 farms and ranches manage about 60 million acres comprising nearly 65% of Montana's total area, and contribute $4.2 billion annually to the State's economy. Today's farmers and ranchers are experiencing different climate conditions than previous generations, and this has prompted discussion about on-going and future management adjustments. Over the last 100 years, the average annual temperature in Montana has increased by 2.4 degrees Fahrenheit (F) with three times as many days above 90°F [1]; yet, since 1950 there has been no statewide trend in changes in precipitation [29]. Expected and already observed risks to crop and livestock production from climate change include longer, hotter growing seasons with an earlier spring arrival, more extreme weather events, and altered distribution of seasonal precipitation with more precipitation in winter, fall, and spring and less in summer [14].

Adaptation on Montana's Farms

Crop Diversification & Changes in Crop Sequencing

- Pulse crops enable producers to diversify their production and cope with increasing variability in temperature and precipitation [2,3].
- Pulse crops have substantial rotational benefits for wheat and barley production including improved soil fertility, increased water use efficiency, and disruption of pest and disease cycles [4].
- By replacing summer fallow with pulse crops, farmers are able to increase cropping intensity while improving soil health and potentially increasing soil moisture retention [5].
- Chickpeas, dry peas and lentils consume less water than spring wheat, making them well-adapted to increasingly hotter summer temperatures [6].

Adaptation vs. Mitigation for Climate Change

Adaptation occurs when natural or human systems adjust to climatic changes or their impacts. Mitigation is a human intervention to reduce the release of greenhouse gas emission (e.g. carbon dioxide, methane, nitrous oxide) or to enhance greenhouse gas sinks (e.g. revegetation, enhancing soil carbon storage).

Changes in Crop Varieties

- Winter wheat yields are less sensitive than spring wheat to increasing summer temperatures [7,8].
- There is growing emphasis on breeding pulse varieties for earliness to flower and mature to take advantage of the moisture available in earlier springs and avoid late-summer drought.
- There is increasing attention on breeding cold-tolerant pea and lentil varieties that can be seeded in fall [4].

Flexible Scheduling

- Under predicted climate scenarios, the growing season is expected to expand. A longer growing season and less harsh winter presents opportunities and challenges, particularly for market garden farmers.
- If moisture is available, an expanded season may enable additional harvests of hay or the cultivation of alternative crops across Montana.
- Earlier springs will allow for earlier seeding of spring-seeded crops.
- Longer growing seasons will allow the growing of longer-maturing crops and varieties.

Managing Weeds, Insect Pests, and Disease in a Warmer Climate

- The range of insect pests is expected to expand due to seasonal changes in moisture and warming temperatures. This could result in higher pest populations, pest growth rates, overwintering, and movement [9].

- Weed management and suppression is going to require new approaches as species like early-maturing weeds such as cheatgrass downy brome may become more prevalent and competitive. Under these conditions, early detection and prevention will be crucial to managing weeds[10].
- To adapt to increased insect pest pressure, researchers are investigating strategies such as strip-cutting alfalfa during harvest which encourages the emigration of natural pest enemies to non-harvested sections, planting grasslands or refugia at field margins to provide habitat for natural enemies, and planting pulse crops in place of summer fallow to disrupt pest cycles[11,12,13,14].

Water Management in a Changing Climate

- Dryland farmers are implementing management techniques to increase soil moisture such as no-till techniques and increased stubble height to retain snow.
- In Montana river basins, such as the Gallatin, Judith, and Big Hole, where the total annual precipitation is more than existing storage capacity, there is interest in augmenting storage capacity to capture spring run-off and buffer summer precipitation shortages.
- Protecting critical riparian areas and encouraging the recharge of alluvial aquifers can enhance natural storage.

Voluntary Water Management Plan

One tool being used across Montana watersheds is the Voluntary Water Management Plan model, which brings together diverse stakeholders to make proactive water allocation decisions during periods of drought. These plans rely on building local relationships, accepting enforcement actions that result in shared sacrifice, and strong community leadership. Voluntary Water Management Plans have been successful in ensuring water access in the face of shifting climate patterns and increasing demands.

Adaptation on Montana's Ranches

Montana's rangeland provides forage for livestock and wildlife.

Recommended Practices for Ranchers

Variable Stocking Rates

- Flexible stocking strategies allow ranchers to more effectively utilize forage, reduce stress on land, and improve resilience for the future depending on the year's conditions[15].
- Recent improvements in animal productivity, health, and live-weight gain rates allow producers to make breed or genetic changes for more efficient animals to graze fewer cattle or have a smaller herd size while still ensuring profitability[16].

Mixed-Crop and Livestock Systems

- Mixed-crop livestock systems are more resilient to climate extremes due to greater system and income diversity[17,30].
- In areas experiencing decreased precipitation and water scarcity, rangeland livestock production is a more drought-resilient option than a mixed crop-livestock system [17].
- Depending on conditions and projections for a given year, producers could manage land on a gradient of practices ranging from solely crop production to a mixed-crop livestock system to solely livestock production.

Coping with Drought

- When possible, producers have boosted resiliency to price and climate uncertainty by investing in irrigation improvements, diversifying operations, starting supplemental outfitting businesses, and reducing operational inputs[18].
- Some ranchers have responded by incorporating both cow-calf pairs and stocker cattle into their operations, weaning calves earlier, and letting pastures rest periodically[19].
- Livestock producers are evaluating calving and lambing dates to adjust for earlier springs.
- Ultimately, ranchers must evaluate adaptive strategies based on individualized costs and benefits, the time scale of their operation, and the risk they are willing to take in implementing those practices[20].

Advances in Technology

- GLOBIOM Global Biosphere Management Model examines the interrelationships of various components in an agricultural system and enables livestock producers to adjust areas dedicated to different activities grazing, watering, night use, etc. according to the identification of more or less productive land [21].
- Improvements in rangeland monitoring practices, such as recent advances in GPS collars, remote sensing and aerial imagery for monitoring, can also help ranchers adapt through increased knowledge of animal behavior trends and changes over time.

Mitigation on Montana's Farms

Agriculture has the potential to play an important role in reducing greenhouse gases and increasing the storage of carbon in the soil. Mitigation strategies aim to reduce the severity and prevalence of climate change. Farmers and ranchers could potentially benefit from mitigation incentives that could provide supplemental on-farm income in compensation for efforts to reduce emissions and increase soil carbon storage.

Capturing Carbon in the Soil

- Farmers can capture carbon by extending crop rotations and including perennial crops that capture more carbon below ground and reduce fallow fields[22].
- If moisture is available, the inclusion of cover crops as temporary vegetative cover between agricultural crops can add carbon to soil and may also capture excess plant-available nitrogen that was not used by the previous crop in the rotation, reducing the release of nitrous oxide, a greenhouse gas [23].
- No-till or minimal till agriculture has become more common across Montana. These low-tillage strategies avoid soil carbon losses by reducing soil erosion and retaining crop residues. There is a scholarly debate about the efficacy of no-till soil management for storing carbon but regardless this cropland management technique has been found to increase soil health, reduce soil erosion, reduce on-farm labor, and save fuel otherwise used to till [24].

Reducing Emissions through Marketing and On-Farm Fuel Efficiency

- Consumer interest in 'Made in Montana' products provides farmers and ranchers the opportunity to sell products at a higher price point while reducing transportation costs and transportation-related greenhouse gas emissions.
- Some farmers and ranchers are reducing greenhouse gas emissions by choosing more fuel-efficient farm equipment when updating machinery and vehicles or running machinery on repurposed cooking oil.

Optimizing Fertilizer Management

- Precision agriculture is an innovative approach that uses machine-mounted crop sensors with aerial or satellite imagery to provide high-resolution spatial data that enables farmers to apply fertilizer differentially across a field based on crop nutrient needs, microclimatic conditions, the cost of the input, and desired yield.
- Farmers can improve fertilizer efficiency by using slow-release fertilizer or inhibitors, shortening the time between fertilizer applications, applying fertilizer directly to soil, and avoiding excess fertilizer or manure application[23].
- Winter cover crops help store soil nitrogen within the root zone, reducing nitrogen losses.

Mitigation on Montana's Ranches

Most mitigation strategies in the livestock sector relate to increasing the amount of carbon stored in rangeland and pasture soils and in woody plants. Opportunities in Montana decreasing carbon loss and increasing carbon storage are high, since Montana is comprised of 65% rangeland and pasture [25].

Carbon Storage on Rangelands and Pastures

- Light or moderate grazing intensity, rather than heavy grazing, conserves stored carbon and limits soil erosion.
- Keeping a field in pasture or rangeland, rather than converting to cropland, will increase carbon storage.
- Replacing annual forage crops in grazing systems with perennial forage crops will help store more soil carbon[26].
- Inter-seeding nitrogen-fixing legumes with grasses may be the best means to increase nitrogen in soil and consequently soil carbon while still producing forage for livestock [27].

Manure Storage and Application

- In mixed-crop livestock systems, using livestock manure as fertilizer reduces use of inorganic fertilizers that contribute greenhouse gas emissions through manufacturing, distribution, and application.
- The appropriate storage or removal of manure slurries, minimization of losses due to volatilization or runoff, and the covering and compaction of farmyard manure can reduce greenhouse emissions[16].

Livestock Feeding Strategies

- Livestock feeding strategies also affect greenhouse gas emission from manure storage, especially in confined livestock operations. If producers optimize nitrogen content of their animals' diet through the use of feed additives and improved feed digestibility, they can reduce methane and nitrous oxide emissions from animals.
- Fewer greenhouse gases are emitted during manure storage and application when livestock consume fresh forage or hay versus grain or silage [28]. Therefore, livestock producers may practice mitigation by feeding cattle less grain and silage and relying more on grazing and feeding hay instead.

Carbon Loss Prevention

- The amount of carbon stored in soil will be maximized when grazing practices maintain optimal amounts of plant litter a.k.a., mulch on the soil surface. Too much and too little mulch limits plant growth, while too little mulch increases soil erosion, soil temperature, and evaporation.
- One recommended practice is to reduce or stop conversion of rangelands into crop production and re-establish permanent vegetation, thus increasing retention of soil organic carbon[27].
- Livestock producers could partner with crop producers to graze cover crops that provide nutritious forage late in the growing season after rangeland plants have matured and lost nutritional value. In return, crop producers benefit when livestock grazing terminates the cover crop and incorporates organic matter and nutrients into the soil without tillage or herbicide application.

References

1. Pederson, G., L.J. Graumlich, D.B. Farge, T. Kipfer & C.C. Muhlfield. 2010. *A Century of Climate and Ecosystem Changes in Western Montana: What Do Temperature Trends Portend?* Climatic Change 98: 133-54.

2. Zentner, R.P., D.D. Wall, C.N. Nagy, E.G. Smith, D.L. Young, P.R. Miller, C.A. Campbell et al. 2002. *Economics of Crop Diversification and Soil Tillage Opportunities in the Canadian Prairies.* Canadian Prairies Journal of Agronomy 94: 216-30.

3. Miller, P.R. & P.A. Holmes. 2005. *Cropping Sequence Effects of Four Broadleaf Crops on Four Cereal Crops in the Northern Great Plains.* Agronomy Journal 97: 189-200.

4. Cutforth, H.W., S.M. McGinn, K.E. McPhee & P.R. Miller. 2007. *Adaptation of Pulse Crops to the Changing Climate of the Northern Great Plains.* Agronomy Journal 99: 1684-99.

5. Larney, F.J., C.W. Lindwall, R.C. Izaurralde & A.P. Moulin. 1994. *Tillage Systems for Soil and Water Conservation on the Canadian Prairie.* In Conservation Tillage in Temperate Agro-Ecosystems. 305-28. Boca Raton, FL: CRC Press.

6. Angadi, A., B. McCarthy, D. Ulrich, H.W. Cutforth, P. Miller, M. Entz, S.A. Brandt & K. Volkmar. 1999. *Developing Viable Cropping Options for the Semiarid Prairies.* Project Rep. Agric. Swift Creek, SK: Agri-Food Canada.

7. Lanning, S.P., K. Kephart, G.R. Carlson, J.E. Eckhoff, R.N. Stougaard, D.M. Wichman & L.E. Talbert. 2010. *Climatic change and agronomic performance of hard red spring wheat from 1950 to 2007.* Crop Science 503: 835-41.

8. Thomson, A.M., R.A. Brown, N.J. Rosenberg, R.C. Izaurralde & V. Benson. 2005. *Climate Change Impacts for the Coterminous USA: An Integrated Assessment-Part 3.* Dryland Production of Grains and Forage Crops. Climate Change 691: 43-65.

9. Lin, B. 2011. *Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change.* BioScience 61: 183-93.

10. Izaurralde, R.C., N.J. Rosenberg, R.A. Brown & A.M. Thomson. 2003. *Integrated Assessment for Hadley Center HadCM2 Climate Change Impacts on Agricultural Productivity and Irrigation Water Supply in the Coterminous United States*. Agriculture for Meteorology 117: 97-122.

11. Hossain, Z., G. Gurr & S.D. Wratten. 2001. *Habitat Manipulation in Luceme medicago Sative L.: Strip Harvesting to Enhance Biological Control of Insect Pests.* International Journal of Pest Management 47: 81-88.

12. Thomas, M.B., S.D. Wratten & N.W. Sotherton. 1991. *Creation of 'Island' Habitats in Farmland to Manipulate Populations of Beneficial Arthropods: Predator Densities and Emigration.* Journal of Applied Ecology 28: 906-17.

13. Krupinsky, J.M., K.L. Bailey, M.P. McMullen, B.D. Gossen & T.K. Turkington. 2002. *Managing Plant Disease Risk in a Diversified Cropping System.* Agronomy Journal 94: 198-209.

14. Derner, J., L. Joyce, R. Guerrero & R. Steele. 2015. *USDA Northern Plains Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies.* United States Department of Agriculture.

15. Derner, J., D. Augustine, L. Porensky, M. Eisele, K. Roberts & J. Ritten. 2016. *Flexible Stocking Strateges for Adapting to Climatic Variability.* United States Department of Agriculture.

16. Herrero, M. 2016. *Greenhouse Gas Mitigation Potentials in the Livestock Sector.* Nature Climate Change 6: 452-61.

17. Weindl, I., H. Lotze-Campen, A. Popp, C. Müller, P. Havlik, M. Herrero, C. Schmitz & S. Rolinski. 2015. *Livestock in a Changing Climate Production System Transitions as an Adaptation Strategy for Agriculture.* Environment Research Letters 10.

18. Yung, L., N. Phear, A. DuPont, J. Montag & D. Murphy. 2015. *Drought Adaptation and Climate Change Beliefs among Working Ranchers in Montana.* Weather, Climate, and Society 7: 281-93.

19. Roche, L. & K. Tate. 2014. *Drought: Ranchers' Perspective and Management Strategies.* Rangeland Watershed Laboratory, UC Davis.

20. Schmidt, D., E. Whitefield & D. Smith. 2014. *Adapting to a Changing Climate: A Planning Guide.* United States Department of Agriculture.

21. Havlik, P., D. Leclere, H. Valin, M. Herrero, E. Schmid, J-F. Soussana, C. Müller & M. Obersteiner. 2015. *Global Climate Change, Food Supply and Livestock Production Systems: A Bioeconomic Analysis.* In Climate Change and Food Systems: Global Assessments and Implications for Food Security and Trade, 176-208. Rome: Food and Agriculture Organization of the United Nations.

22. West, T.O. & W.M. Post. 2002. *Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation: A Global Data Analysis.* Soil Science Society American Journal 66: 1930-46.

23. Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kuman, B. McCarl, et al. 2008. *Greenhouse Gas Mitigation in Agriculture.* Philosophical Transactions of the Royal Society B 363: 789-813.

24. Powlson, D.S., C.M. Stirling, M.L. Jat, B.G. Gerard, C.A. Palm, P.A. Sanchez & K.G. Cassman. 2014. *Limited Potential of No-till Agriculture for Climate Change Mitigation.* Nature Climate Change 4: 678-83.

25. Sommer, E. 2015. Montana 2015 Agricultural Statistics. Montana Department of Agriculture.

26. Soussana, J-F., K. Klumpp & T. Tallec. 2009. *Mitigating Livestock Greenhouse Gas Balance through Carbon Sequestration in Grasslands*. IOP Conference Series: Earth and Environmental Science 624.

27. Derner, J. & G. Schuman. 2007. *Carbon Sequestration and Rangelands: A Synthesis of Land Management and Precipitation Effects.* Journal of Soil and Water Conservation 622.

28. Chadwick, D., S. Sommer, R. Thomas, D. Fangueiro, L. Cardenas, B. Amon & T. Misselbrook. 2011. *Manure Management Implications for Greenhouse Gas Emissions.* Animal Feed Science and Technology 166-167: 514-31.

29. Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA. 2017. The Montana Climate 46 Assessment: stakeholder driven, science informed. Full citation forthcoming.

30. Mu, J., B. McCarl, and A. Wein. 2013. Adaptations to Climate Change: Changes in Farmland Use and Stocking Rate in the U.S. Mitigation and Adaptation Strategies for Global Change 18: 713-30.

To order additional publications, please contact your county or reservation MSU Extension office, visit our online catalog at **store.msuextension.org** or e-mail **orderpubs@montana.edu**

MONTANA STATE UNIVERSITY | EXTENSION

File under: Agriculture and Natural Resources (Climate)
New July 2017 0717SA